

## Modified constraint-induced movement therapy versus mirror therapy on affected hand functions in hemiparetic children

Constraint therapy versus mirror therapy in hemiparetic children

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### Abstract

**Aim:** This study aimed to examine the efficacy of Modified Constraint-Induced Therapy versus mirror therapy for hand function in children with right hemiparetic cerebral palsy.

**Material and Methods:** Forty children with hemiplegic CP participated in this study. All subjects were with right side affected, grade 1+ spasticity and level III of MACS, aged 5 to 8 years, were selected for this randomized study and randomly assigned into two equal groups. The control group (A) received mCIMT for 3 hours daily 5 days / week for consecutive 4 weeks and the other group (B) received mirror therapy for 30 minutes daily 5 days / week for consecutive 4 weeks. Both groups received regular intensive physical and occupational therapy apart from the above interventions. The data obtained from both groups pre- and post-treatment on the QUEST scale were statistically analyzed and compared.

**Result:** There was a significant increase in the QUEST scale for Group A compared with that for Group B post treatment ( $p = 0.0001$ ). The obtained findings clearly suggest that Modified constraint induced movement therapy (MCIMT) is more effective than mirror therapy in improving functions of the affected hand in children with Hemiparetic cerebral palsy.

**Discussion:** Children with motor dysfunction could be improved using targeted functional training. The use of modified constraint-induced movement therapy and mirror therapy are strategies for achieving motor recovery.

### Keywords

Cerebral palsy; Constraint therapy; Mirror therapy; Hand function

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## Introduction

Cerebral Palsy (CP) describes “a group of motion and posture developmental disorders that induce functional limitations are associated with non-progressive defects that have occurred in the growing fetal or infant brain” [1]. Hemiparetic cerebral palsy is a type of cerebral palsy that affects one arm and one leg on either the right or left side of the body and the upper limb is typically more involved than the lower limb. It is the most prevalent form of cerebral palsy disorders among full term-born infants, but is second in prevalence to spastic diplegia in premature infants [2]. Reduction of upper extremity control can result from a sensory impairment, poor gripping, loss of fine-sequencing finger movements, loss of accuracy and speed, loss of dexterity, associated and mirror movements, preservation of grasp reflex and hypertonia [3]. With time, these children neglect the affected arm, which can lead to additional dysfunction, such as increased muscle tone, reduced motor coordination, diminished active and passive flexibility of the limb joints, overall weakness, and slow skeletal maturation [4]. Children with hemiparetic cerebral palsy learn tactics and methods to perform everyday activities and play with unaffected hand. Thus, the other hand, even though it is not impaired to a larger degree, is not included in practical tasks. This is called learning not to use the affected hand as if it were missing or amputated [5]. Treatment approaches for children with hemiparetic Cerebral palsy include neurodevelopmental therapy, bilateral therapeutic exercises, constraint-induced movement therapy, sensory integration therapy, and mirror-mediated therapy [6]. Constraint-induced movement therapy (CIMT) is defined a restriction of the less affected upper limb, with repeated task-oriented exercises for the more affected upper extremity in order to overcome the acquired non-use syndrome of the hemiplegic upper extremity and achieve functional rehabilitation [7]. Restriction of the less affected limb can help balance hemispheric behavior. Training the more affected limb offers more advantages to ipsilesional corticospinal Tract. This might restrict the displacement of the intact Contralateral corticospinal tract projections in the affected hemisphere by enhancing more active projections in the un affected hemisphere [8]. Intensive use of the more affected limb induces the development of the contralateral cortical area regulating the motion of the more affected limb” and recruits new ipsilateral regions, this may act as a neurological foundation for a permanent increase in the use of the affected limb post treatment [9]. Constraint-induced movement therapy (CIMT) has been recognized as a tool for training a child to use the affected upper limb using a splint or glove restraint on the unaffected limb [10]. Mirror therapy is another therapeutic intervention that focuses on moving the unimpaired limb. It is a procedure that is meant to enhance physical control of the affected limb in people with hemiplegia after a stroke and in children with spastic hemiparetic cerebral palsy [11]. Therefore, this study may determine which method has a better effect on improving clinical outcomes in these children including the effect on “dissociated movement, grasps, protective extension, and weight-bearing”.

## Material and Methods

### Subjects

This study included 40 patients with a diagnosis of Right hemiparetic cerebral palsy. Children with any other problems than right hemiparesis were excluded, such as contractures, suffering from fixed limitations in the affected upper limb, poor skin integrity or marked edema, or Any visual or auditory abnormality.

### Materials:

1. Mitt (Figure 1): used to constraint the unaffected hand in Group A.
2. Mirror box (Figure 2): A Mirror box is a device which allows the clinician to easily create this illusion. It is a box with one mirror in the center, where on each side, the hands are placed in a manner that the affected limb is kept covered always and the unaffected limb is kept on the other side whose reflection can be seen on the mirror [12].

### Procedures:

#### Study design

A randomized study included forty children with right hemiparetic cerebral palsy selected from the out-patient clinic, Faculty of Physical Therapy, Cairo University (males and females, aged 5 to 8 years). Those meeting the criteria of inclusion were divided according to the type of intervention into 2 groups (A and B). Group A involved 20 children who will receive modified constraint-induced movement therapy 3 hours/ day “5 times per week” for 4 weeks. Group B involved 20 children who will receive mirror therapy, 30 minutes / day “5 times per week” using a mirror box for 4 weeks. Both groups will receive regular intensive physical and occupational therapy apart from the above interventions

#### Ethical consideration

This study was approved by the Cairo University Research Ethics Committee, and written informed consent was obtained from the parents of each subject to participate in this study.

#### Participant recruitment

All children were randomly assigned equally in two groups using the closed envelopes procedure (40 children each).

#### • For Selection

1- Modified Ashworth Scale for selecting children (MAS):

The modified Ashworth scale is the most universally accepted clinical tool used to measure the increase of muscle tone [13].

All subjects selected in this study were graded 1+ using MAS.

2- Manual Ability Classification System for children with cerebral palsy “4-18 yrs.” (MACS):

The Manual Ability Classification System (MACS) was developed to classify how children with cerebral palsy (CP) use their hands when handling objects in daily activities. The classification is designed to reflect the child’s typical manual performance, not the child’s maximal capacity. The MACS covers the age group between 4 and 18 years at levels ranging from I to V. The children at the level I are able to handle objects easily, those at level II handle most objects but with a little reduced quality or speed, and those at level III handle objects with difficulty and need help to prepare or change activities. At level IV, children handle a limited quantity of objects and require continuous

support to partially conclude the activities, and at level V, the children do not handle objects [14].

All subjects selected in this study are leveled 3 using MACS.

• **For assessment**

**QUEST**

The QUEST is a criterion-referenced measure that assesses upper limb movement on 34 items divided into four domains, with administration and scoring reported to take between 30 and 45 minutes. The QUEST was also constructed to be a discriminative measure of the quality of movement, measuring components of hand function, and providing information about movement and postural responses [15]. The QUEST was developed for children aged 18 months to 8 years with muscle spasticity resulting from neurological impairment and affecting the upper extremities [16]. The QUEST groups upper limb movement into four domains. Each domain focuses on areas of difficulty typically seen in children with spastic cerebral palsy: (a) Dissociated Movements, (the ability to voluntarily isolate movement at the shoulder, elbow, wrist and fingers); (b) Grasps (which also rates sitting postures during grasps of 1-inch cube, cereal, pencil or crayon); (c) Weight Bearing (the ability to lean on the arms in prone or 4-point kneeling, sitting and while reaching); and (d) Protective Extension (using the arms to stop oneself from falling forward, backward and to the side).

QUEST was used for assessment of both groups pre-and post-treatment.

• **Interventions**

1. Modified Constraint Induced Movement Therapy

Group A Used Mitt for constraining the left hand 3 hours/ day “5 times per week” for 4 weeks, in addition to the selected physical therapy exercises (1.5 hours/ day “3 times per week”) for 4 weeks.

2. Mirror Therapy

Group B received Mirror therapy for 30 minutes / day “5 times per week” using a mirror box for 4 weeks, in addition to the selected physical therapy exercises (1.5 hours /day “3 times per week” for 4 weeks).

They were asked to perform activities with the unaffected hand while looking in the mirror. The mirror box was placed on a table of appropriate height so that she was able to see the reflection with back supported. The forearm was supported on the table. The right upper limb was placed inside the mirror box with the elbow supported. Activities performed by the right hand included grasps of cylindrical using cups, bottle, spherical using plastic balls of various diameter and hook grasp using rings and handles pattern objects. Gripping activities with Thera putty, pins board for training pincer pattern, attaching and detaching the chains using pulp-to- pulp prehension pattern. Transfer of cubes from one box to other with only left hand.

Selected physical therapy exercises include:

- 1- Strength exercises for weak wrist extensors, forearm supinator, and for intrinsic muscles of the affected hand.
- 2- Stretching exercises for wrist flexors, fingers flexors and forearm pronators.
- 3- Upper limb weight bearing exercises and Overhead activities.
- 4- Grasping and releasing small objects in a container.
- 5- Building a tower with cubes.
- 6- Balance training.

**Statistical analysis**

Descriptive statistics and unpaired t-test were conducted for comparison of age between groups. The Chi- squared test was used for comparison of sex distribution between groups. The normal distribution of the data was checked using the Shapiro-Wilk test. Levene’s test for homogeneity of variances was conducted to test the homogeneity between groups. The Unpaired t-test was conducted to compare the mean values of the QUEST scale between groups. Paired t-test was conducted for comparison between pre- and post-treatment in each group. The level of significance for all statistical tests was set at  $p < 0.05$ . All statistical analyses were conducted using the statistical package for social studies (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA).

**Results**

**Subject characteristics:**

Forty children with hemiplegic CP participated in this study. All subjects were with right side affected, grade 1+ spasticity and level III of MACS. There was no significant difference between the groups in age and sex distribution ( $p > 0.05$ ).

**Effect of treatment on QUEST scale**

- Within group comparison:

There was a significant increase in the QUEST scale post treatment compared with that pretreatment in groups A and B ( $p > 0.001$ ). The percent of increase in the QUEST scale in group A was 10.84%, while that in the group B was 5.66% (Table 1, Figure 3).

- Between groups comparison:

There was no significant difference in the QUEST scale between both groups pre-treatment ( $p > 0.05$ ). Comparison between groups post treatment revealed a significant increase in the QUEST scale for Group A compared with that for Group B ( $p > 0.001$ ) (Table 1, Figure 3).

**Table 1.** Basic characteristics of participants

	Group A	Group B	p-value
	Mean ± SD	Mean ± SD	
Age (years)	6.5 ± 1.15	6.55 ± 1.14	0.89
Sex, n (%)			
Girls	9 (45%)	11 (55%)	0.52
Boys	11 (55%)	9 (45%)	

SD, standard deviation; p-value, level of significance

**Table 1.** Mean QUEST scale pre- and post-treatment in groups A and B:

QUEST scale	Group A	Group B	MD	t- value	p value
	mean ± SD	mean ± SD			
Pre treatment	62.81 ± 2.45	63.25 ± 2	-0.44	-0.63	0.53
Post treatment	69.62 ± 2.34	66.83 ± 1.61	2.79	4.37	0.001
MD	-6.81	-3.58			
% of change	10.84	5.66			
t- value	-21.17	-17.31			
	p = 0.001	p = 0.001			

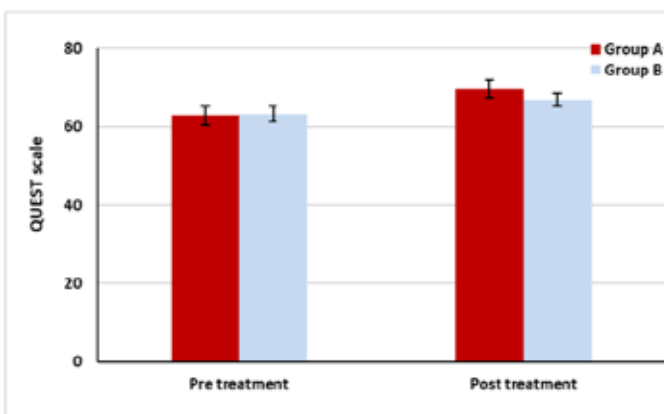
SD, standard deviation; MD, mean difference; p-value, probability value



**Figure 1.** Mitt



**Figure 2.** Mirror box



**Figure 3.** Mean QUEST scale pre- and post-treatment in groups A and B.

**Discussion**

In all aspects of daily life, we carry out tasks involving the use of two hands, children with unilateral cerebral palsy, at all ages, who suffer diminished function with one hand, will continue to experience difficulties with daily occupational performance, affecting their involvement in life circumstances [1]. As

mentioned, if hemiplegic children use the upper unaffected extremity and neglect the affected upper extremity, they will lose their functional independence. This leads to theories that patients would gradually use the hemiplegic upper extremity and potentially reach functional improvement if they undergo short-term intensive rehabilitation programs such as modified constraint induced movement therapy or mirror therapy [18]. In this study, both the mCIMT and mirror therapy groups showed improvements in the QUEST results, but the mCIMT group showed better QUEST results, and better hand function that was significantly correlated to dissociated movements, grasping, weight-bearing and protective reactions. The main difference between the mCIMT group and the mirror therapy group was that patients in the mCIMT group tried to move their affected arm, while those in the mirror therapy group did not. The intention to move the affected extremity is a notable difference between the two groups. In the Mirror therapy group, the affected limb does not engage in the task, but in the mCIMT group, there was an attempt to execute movement with the affected hand, which is necessary to reorganize the motor areas in the brain, resulting in motor skill improvement and higher performance on ADL [19]. The reflection illusion of normal activity of the affected hand may substitute for reduced proprioceptive input, thus working to promote the premotor cortex and helping rehabilitation through a strong connection between visual input and the premotor regions. Improvements in Fugl-Meyer Assessment and fine motor movements have been recorded after a 3-to 4-week course of mirror therapy in patients with stroke. As a result, it has been shown to be successful in enhancing the range, velocity and precision of motion in the hemiplegic upper extremity [20]. The findings of this study indicate that both mCIMT and mirror therapy improve hand function in hemiparetic cerebral palsy children, but mCIMT is significantly more effective in improving upper limb function in those children than mirror therapy. The findings of this study are in agreement with those of El-Kafy et al. who examined the effectiveness of a mCIMT protocol in improving upper extremity function in children with congenital hemiplegic cerebral palsy and reported improvement in functions of the affected hand [21]. A study was conducted by Yumi Ju et al. to determine if therapies affect the function of the upper extremity and the ability to perform daily tasks, and they reported that mCIMT and mirror therapy significantly improves the motor function of affected hand [22]. Further study has found that, after the implementation of CIMT, significant neuroplastic improvements in brain organization and function have occurred in people who have undergone the CIMT protocol [23]. The modified form of restriction therapy (immobilization of the unaffected limb without intense motor training) also results in functional progress in children with cerebral palsy and contributes to cortical reorganization in children with hemiplegic cerebral palsy [24]. Kim and Lim reported that mirror-mediated therapy conducted for 4 weeks (60 min/time, 5 days/week) had a beneficial effect on upper limb control, sensory function, and ADL in patients with chronic stroke-concomitant hemiplegia. In comparison, the experimental group demonstrated a strong recovery of hand function in more areas than the control group did in the Woo et al. study [25].

**Conclusion:**

The Modified constraint induced movement therapy (MCIMT) is more effective than mirror therapy in improving functions of the affected hand for the children with hemiparetic cerebral palsy.

**Scientific Responsibility Statement**

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

**Animal and human rights statement**

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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**Conflict of interest**

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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